Generation-X

Power System Overview

Diane Yun

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Power
Topics

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- Solar Array Configuration
- Battery
- Power System Electronics (PSE)
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Power
System Overview

- **Solar Array for Options #3-5**
  - Option #2: Body Mounted solar cells on cylinder
  - Option #3-4: Fixed, Deployed solar array
  - Triple Junction GaAs solar cells
- **Battery (for peak power modes & contingency)**
  - 100Ah Lithium Ion battery
- **DET Power Electronics**
  - MAP-like with modifications

Power
Driving Requirements & Assumptions

- **Launch date: Year 2015**
- **Mission life: 3-5 years**
- **L2 orbit, No eclipse during mission**
- **Power during transfer from LEO to L2 = 10 kWatts for 1 day**
  (Power & Time estimate to get beyond the radiation belts)
- **Thermal + propulsion power = 2000 Watts**
- **Total power requirement:**
  - Nominal Operations = 2775 Watts
  - Peak Mode = 3329 Watts

Loads Summary

Load Profile,000710						
Generation X						
3-5 year Mission						
				Transfer to L2	**Nominal Power: (Day)**	**Peak**
				Avg. Power	Avg. Power	Peak Power
Time Period Over Which Averaging Is Done For Each		Margin (%)		Max: 1 day	Mission Life	Mission Life
Total Power				**10000.0**	**2774.2**	**3328.5**
Instrument Totals with Margin		0		0.0	200.0	200.0
	Imaging Spectrometer			0.0	200.0	200.0
	Large area X-ray Mirror			0.0	0.0	0.0
Spacecraft Loads--Margined				10000.0	2574.2	3128.5
Power				0.0	55.0	55.0
	MAP PSE scaled for 2000W load	10		0.0	50.0	50.0
Electrical				0.0	44.0	44.0
	PSDU			0.0	20.0	20.0
	Ha rness			0.0	20.0	20.0
	Ha rness -- 200 Watts to detector			0.0	4.0	4.0
Attitude Control				0.0	73.4	517.4
	ACE			0.0	22.0	26.0
	Coarse Sun Sensor			0.0	0.0	0.0
	Digital Sun Sensor			0.0	1.4	1.4
	IRU			0.0	22.0	40.0
	Star Tracker			0.0	0.0	10.0
	Reaction Wheel (peak for 1-3 hrs for every maneuver)			0.0	28.0	440.0
Command & Data Handling		15		0.0	23.0	23.0
				0.0	20.0	20.0
Communications		15		0.0	20.8	131.1
	S-Band Transponder			0.0	8.3	38.0
	X-Band SS 10 w PA (includes modulator & exciter)			0.0	8.8	60.0
	X-Band HGA and gimbals			0.0	1.0	16.0
Thermal		20		0	2400	2400
	Heaters			0	2000	2000
Propulsion		15		10000	2	2

Transfer to L2
Options Considered

Required to provide 10 kWatts power for 1 day during transfer to L2

(Power & Time estimate to get beyond the radiation belts)

♦ Primary Battery - Lithium Thionyl Chloride -- 240 kWh

- Estimated mass, using 400 Wh/kg
  (currently for a 24 hour discharge ~300-350Wh/kg)
- Mass = 600 kg
- In 15 years, most likely will increase to 450-500Wh/kg

♦ Fuel Cells

- Minimum mass is ~900 kg
- More expensive than batteries

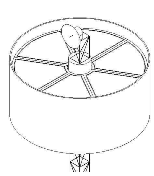
♦ Turbo-Alternator (ISS)

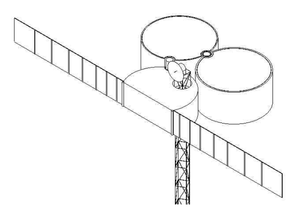
Power
Solar Array Configuration

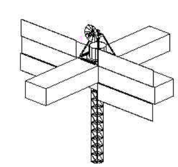
- **Total Effective Area Required for 3000W Load is 15.8m^2**
- **Power at BOL = 3400 Watts**
- **Power at EOL = 3000 Watts**

	Option #3	Option #4	Option #5
Solar Array configuration	• Body-mounted • 1/2 of cylinder covered with solar cells	• Deployed, fixed • Each panel is 1m x 1.5m • 2 wings	• Deployed, fixed • Each panel is 4.2m x 1m • Mounted and deployed from modules
Minimum Area Required*	6.2m x 2.6m (Diameter x Height)	2 wings, each with 5.5 panels Total Area = 15.8 m^2	2 panels per module Total of 4 panels, Total Area = 15.8 m^2
Mass	34 kg	68 kg	68 kg

* All options have more area available for solar array, if needed







Solar Array
Sizing Assumptions

- 28% Efficient (BOL) Triple Junction GaAs cells
- No shadowing
- 85% Packing factor
- Includes losses from Temperature, Radiation, UV, Thermal cycling, assembly losses, and losses from SA to battery, battery to load, & SA to load.
- Used .9479suns for sun intensity (Sun intensity at L2 during summer)

- Mass includes solar cells, 6 mil thick coverglass, harness, connectors, etc. For the options with the solar array deployed, mass also includes the honeycomb structure and substrate. The mass number does not include hinges, deployment mechanisms, etc.

Battery Required for Peak Power & Contingency

Lithium Ion Battery, 100 Ah

- During maneuvers, there is an additional 444W load required for ACS.
- At EOL, the S/A can provide 225W. The other 219W will be provided by the battery.

- A 100 Ah battery (60% DoD) can provide:
  - 345 Watts for 1 hr
  - 219 Watts for 1.6 hrs.
  - 170 Watts for 2 hrs
  - 115 Watts for 3 hrs.

Power System Electronics

♦ DET PSE

- like MAP
  - Battery Charge controller Module
  - Individual cell monitors - voltage, current, temp.
  - Solar Array Module
- Will need modifications to:
  - Monitor and Control Lithium Ion battery
  - Add a 120V converter for the Detector instrument power (200W)

♦ Getting power to Detectors (200W)

- 120V reduces current and mass
- Use a pair of AWG#22 wires to provide power to Detector instrument
- Mass of 2 pairs of wire (+V & Return) = 5 kg

Power
Additional Trades to Consider

- **Do a trade study to determine optimum system for power to Detector instrument**
  - Need to consider:
    - Provide power to Instrument vs. Individual power system for Instrument
    - Mast deployment
    - Wire size (mass) vs. power losses
    - Optimum bus voltage

- **New technology to provide the 10 kWatts for 1 day (transfer power)**

- **Placement of solar arrays/cells to aid thermal design**

Power
Risk Assessment

- **Highest risk item is providing power to the Detector Instrument**
  - Need further study to determine optimum design
  - Inquire with Harness group for their expertise

- **Solar Array**
  - TJ GaAs solar cells - assumed technology advancement
- **Battery**
  - Li-Ion batteries - assumed technology advancement
- **PSE**
  - low risk

Power
Summary

- Power sub-system is not a major driver for this mission
- When power numbers are refined, Solar Array size and battery size can be optimized (including contingency)
- Technology advances will most likely occur with higher efficiency solar cells, higher energy density batteries (lower mass), and more efficient electronics.